Ministry of Water, Land and Air Protection

OVERVIEW — ARSENIC

WATER BC our vital resource

Water Quality

GUIDELINES

DOC
BC
W3246
D:A42A7
2002
c.3

LEGISLATIVE LIBRARY OF BRITISH COLUMBIA
3 3298 00200 0090

102-03407/

WATER PROTECTION BRANCH
ENVIRONMENTAL PROTECTION DIVISION
MINISTRY OF WATER, LAND AND AIR PROTECTION

AMBIENT WATER QUALITY GUIDELINES FOR ARSENIC

OVERVIEW

Prepared pursuant to Section 2(e) of the
Environment Management Act, 1981

Approved: _____ _____ for
M. Eckenfelder

Date Assistant Deputy Minister

LEGISLATIVE LIBRARY
VICTORIA BC V8V 1X4 MAR 04 2002

National Library of Canada Cataloguing in Publication Data
Main entry under title:
Ambient water quality guidelines for arsenic [electronic resource]

Available on the Internet.
Available also in printed format on demand.
Based on the Canadian Council of Ministers of Environment (CCME) Water Quality Guidelines for Arsenic (2001 update). Cf. Summary.
Includes bibliographical references: p.
ISBN 0-7726-4703-8

1. Water quality - Standards - British Columbia.
2. Arsenic - Environmental aspects - British Columbia.
3. Subject - British Columbia. I. British Columbia. Water Protection Branch.

TD227.B7A45 2002 363.738'4 C2002-960021-9

SUMMARY

THIS DOCUMENT is one in a series which establishes ambient water quality guidelines for British Columbia. It is based on the Canadian Council of Ministers of Environment (CCME) Water Quality Guidelines for Arsenic (2001 update). This overview report assesses those guidelines for use in British Columbia.

The guidelines are safe conditions or levels which have province-wide application and are set to protect various water uses. This report sets guidelines for arsenic, as appropriate, to protect drinking water, freshwater and marine aquatic life, irrigation, and livestock watering. The CCME guidelines were judged to be sufficiently protective of water uses in the province of British Columbia and were adopted without change.

The guidelines are summarized in Table 1 on the following page.

A major use of the guidelines is to set ambient water quality objectives. The objectives are the guidelines modified or adopted to protect the most sensitive designated water use in a particular body of water. The objectives are used in the preparation of waste management plans, pollution prevention plans, waste management permits, orders, or approvals. The latter three are the only documents that have legal standing.

TABLE 1: SUMMARY OF WATER QUALITY GUIDELINES FOR ARSENIC

Water Use	Recommended Guideline† (µg/L)
Source Drinking Water	25*
Aquatic Life	
Freshwater	5
Marine, estuarine	12.5*
Agriculture	
Irrigation	100*
Livestock Watering	25*
Wildlife	25*
Recreation and Aesthetics	None recommended

† Total arsenic
* Interim guideline

PREFACE

THE MINISTRY OF WATER, LAND AND AIR PROTECTION develops ambient water quality guidelines for British Columbia. This work has two goals:

- to provide guidance for evaluating data on water, sediment and biota, and
- to provide a basis for setting site-specific ambient water quality objectives;

The guidelines represent safe conditions or safe levels of a substance in water. The term "guideline" is defined as "a maximum and/or a minimum value for a physical, chemical or biological characteristic of water, sediment or biota, which should not be exceeded to prevent detrimental effects from occurring to a water use under given environmental conditions."

Water Quality guidelines are applied province-wide, but they are use-specific, and are being developed for these water uses:

- raw drinking water, public water supply and food processing[1]
- aquatic life and wildlife
- agriculture (livestock watering and irrigation)
- recreation and aesthetics[2]
- industrial water supplies

The guidelines are established following a thorough review of the recent scientific literature, guidelines set by other jurisdictions, and environmental conditions in British Columbia. The scientific literature provides information on environmental fate, persistence, and effects of toxicants on various life forms. This information is not always conclusive because it is often based on laboratory testing that, at best, only approximates field conditions. To compensate for this uncertainty, and applying the "precautionary principle", the guidelines have built-in safety factors that are conservative, while taking into account the natural background in the province.

[1] The guidelines apply to an ambient raw water source before it is diverted or treated for domestic use. The Ministry of Health Planning regulates the quality of purveyed water.

[2] Guidelines relating to public health at bathing beaches are the same as those developed by the Ministry of Health Planning, which regulates the recreation and aesthetic water use.

The guidelines are used to set ambient site-specific water quality objectives for specific waterbodies. In setting the objectives, considerations are given to present and future water uses, waste discharges, hydrology, limnology, oceanography, and ambient water quality conditions at the site in question.

In most cases, the objectives are the same as the guidelines. However, when natural background levels of substances exceed the guidelines, the site-specific objective could be less stringent than the guideline in order to take this high natural level into account. In rare instances—for example, if the resource is unusually valuable or of special provincial or ecological significance—the safety factor could be increased enabling objectives to be more stringent than the guidelines. Another approach would be to develop site-specific objectives by conducting toxicity experiments in the field. However, because this approach is costly and time consuming, it is seldom used.

Neither the guidelines nor the objectives derived from them have any legal standing. However, objectives can be used to calculate waste discharge limits for contaminants. These limits are outlined in waste management permits, orders and approvals, all of which have legal standing. Objectives are not usually incorporated as conditions of a permit.

Water quality guidelines are subject to review and revision, as new information becomes available or as other circumstances dictate.

RECOMMENDED GUIDELINES

THESE GUIDELINES are based on the Canadian Council of Ministers of Environment (CCME) Water Quality Guidelines for Arsenic (June 1997 update) and are summarized in Table 1.

1 RAW DRINKING WATER SUPPLY

The Interim Maximum Acceptable Concentration (IMAC) of 25 µg/L recommended by Health Canada for total arsenic in water to be used for drinking in the 'Guidelines for Canadian Drinking Water', has been accepted by the Ministry of Health Planning for application in British Columbia.

Rationale

Most drinking water supplies in British Columbia are treated only by disinfection. Hence the raw water supply must be of sufficient quality to meet the guidelines for withdrawal from the system.

It should be noted that in April 2001 the U.S. EPA ordered an expedited review of arsenic toxicity in a range of 3 to 20 µg/L for the establishment of a new Drinking Water Standard (DWS). This followed a move by the U.S. EPA in January 2001, to reduce the DWS from 50 µg/L to 10 µg/L based on concerns that arsenic in drinking water causes bladder, lung, and skin cancer, and possibly kidney and liver cancer. This move was overruled because the initial evaluation was judged to be too rushed. Conclusions reached by the U.S. EPA may warrant a future review of the Canadian Drinking Water Guideline for arsenic.

2 AQUATIC LIFE

These guidelines are designed to protect aquatic life in fresh, estuarine and coastal marine waters from excessive arsenic released to the environment as a result of human activities.

To protect freshwater aquatic life, the Canadian Council of Ministers of the Environment (CCME) set a guideline of 5 µg/L for total arsenic. To protect marine life, the CCME set an interim guideline of 12.5 µg/L. These national guidelines have been evaluated and judged to be acceptable without change for use in British Columbia.

2.1 Freshwater Aquatic Life

- *the maximum concentration of total arsenic should not exceed 5.0 µg/L.*

Rationale

A review of the available literature revealed that the invertebrate *Daphnia magna* (common throughout British Columbia) was the most sensitive freshwater organism to arsenic. U.S. pesticide regulatory tests yielded a Lowest Observed Effect Concentration (LOEC) for growth of 38 µg/L for arsenic acid (H_3AsO_4) which is equivalent to 20 µg/L as arsenic, in a 21-d flow-through chronic bioassay. The No Observed Effect Concentration (NOEC) was determined to be 20 µg/L arsenic acid that is equivalent to 10.5 µg/L arsenic.

The CCME Water Quality Guideline is based on toxicity tests using the green alga *Scenedesmus obliquus* (common throughout British Columbia), the most sensitive freshwater algae exposed to arsenic. A 14-d EC50 demonstrated growth inhibition at a concentration of 50 µg/L. The CCME guideline was derived by multiplying this concentration by an application factor of 0.1 to yield the water quality guideline of 5.0 µg/L to protect freshwater aquatic life. Separate growth tests performed by other researchers on *Scenedesmus obliquus* determined 96h EC50's of 78.7 and 159.3 µg/L (as As) for arsenite [As(III)] and arsenate [As(V)], respectively. In another series of tests on two other algal species (*Melosira granulata* and *Ochromonas vallesiaca*), researchers determined an EC50 of 75 µg/L for both. These additional tests provide weight-of-evidence support for the *S. obliquus* results.

While the use of the *D. magna* LOEC (20 µg/L) to derive the guideline of 5 µg/L yields a lower margin of safety (four times) than that (ten times) applied to the algal EC50 of 50 µg/L by the CCME, it is important to note that the guideline is still two-fold lower than the NOEC for *D. magna*. In view of this LOEC/NOEC relationship, a guideline of 5 µg/L was judged to provide adequate protection to aquatic life in British Columbia.

Freshwater fish demonstrated lower sensitivity to arsenic than either invertebrates or algae. The lowest chronic LC50 for fish reported in the

literature was 550 µg/L for rainbow trout (*Oncorhynchus mykiss*) after 28-d exposure.

2.2 Marine and Estuarine

- *the maximum concentration of total arsenic should not exceed 12.5 µg/L.*

Rationale

The toxicity of arsenic to algae is dependent on the oxidation state of arsenic and on the concentration of phosphorus in the water. The marine red algae *Champia parvula* (common in British Columbia coastal waters) was more sensitive to arsenite [As(III)] where sexual reproduction ceased at concentrations between 60 and 95 µg/L (geometric mean = 75.5 µg/L) . A phosphorus concentration up to 9.1 µM had little effect on As (III) toxicity. Arsenate [As(V)] toxicity was inversely proportional to the amount of phosphorus present.

The CCME arsenic guidelines for marine and estuarine waters is based on the LOEC of 125 µg/L for growth reduction of the red alga *Skeletonema costatum*. The CCME Guideline was derived by multiplying this concentration by an application factor of 0.1 to yield the water quality guideline of 12.5 µg/L. Even though the CCME guideline was not based on the most sensitive study, the 10-fold safety factor applied to the *S. costatum* data was judged to provide ample protection (~5 to 6-fold) for *C. parvula* given a NOEC for inhibition of sexual reproduction at 60 µg/L and a calculated threshold effect level of 75.5 µg/L.

3 AGRICULTURE

3.1 Irrigation

- *the maximum concentration of total arsenic should not exceed 100 µg/L.*

Rationale

This CCME interim guideline for irrigation is based on the LOEC for reduced growth in green beans (*Phaseolus vulgaris*) which are reported as the most sensitive of 25 crop species tested. A 42% reduction in growth was reported in a soil arsenic concentration of 11.2 mg/kg. By calculating the Species Maximum Acceptable Soil Concentration (SMASC) for green beans (0.37 mg/kg soil), applying an uncertainty factor of 10, and taking into consideration the soil bulk volume to a depth of 25 cm and the irrigation rate, an interim guideline of 100 µg/L for arsenic in irrigation water was derived. This interim CCME guideline

was judged to be sufficiently protective for agricultural crops in British Columbia and was adopted without change.

3.2 Livestock Watering

- *the maximum concentration of total arsenic should not exceed 25 µg/L.*

Rationale

This CCME interim water quality guideline for livestock watering is based on a LOEC of 2.2 mg/kg for reduced growth and longevity in the beagle dog (*Canis domesticus*). The beagle dog was the most sensitive of 13 mammalian and 9 avian species tested. A 10-fold safety factor was applied to the calculated Acceptable Daily Intake (ADI) for beagles which was used to derive a Reference Concentration (RC) of 0.35 mg/L. To account for exposure to arsenic from sources other than water, an apportionment factor of 0.2 was applied to derive an interim water quality guideline of 71 µg/L.

However, the CCME protocol for the derivation of Water Quality Guidelines for livestock watering recommends that the lower of either the interim livestock or Drinking Water Quality Guidelines be adopted as the Interim Water Quality Guideline for livestock. The Drinking Water Quality Guideline is 25 µg/L.

4 WILDLIFE

- *the maximum concentration of total arsenic should not exceed 25 µg/L.*

Rationale

The rationale for this guideline is the same as that specified for Livestock Watering (Section 3.2).

APPLICATION OF GUIDELINES

To determine the applicability of the recommended freshwater aquatic life guideline, an historical assessment of potential exceedence of the recommended freshwater aquatic life guideline of nearly 5000 samples taken at 31 sites throughout British Columbia was undertaken. Approximately 2% of these samples exceeded the recommended guideline of 5 µg/L total arsenic. It should be noted that while the guideline may have been exceeded in some cases, such occurrences do not assure a toxicological event. Some forms of arsenic may be complexed with other substances such that they are not biologically-available and therefore unable to interact with cellular mechanisms. To assess the impact of

arsenic in situations where the guideline is exceeded yet aquatic life seems to thrive, we recommend that the Ministry publication, *Methods for Deriving Site-Specific Water Quality Objectives in British Columbia and Yukon*, available on the Ministry of Water, Land and Air Protection website be consulted at: http://wlapwww.gov.bc.ca/wat/wq/BCguidelines/effectsratio.html .